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(54) A process and appartatus for the continuous annealing of metallic material in the presence of hydrogen-rich protective gas

(57) The invention relates to a process for the annealing of metallic material in a continuous fashion in a continuous annealing apparatus in which a hydrogen-rich protective gas atmosphere is maintained by a suitable supply of appropriate starting media, wherein the material to be annealed is consecutively heated, annealed and cooled again and wherein the cooling is carried out in a cooling zone of the annealing apparatus supported by coolers. In such annealing processes so-called white dust is formed during the annealing process, by which the aforementioned coolers become increasingly clogged with progressive operating time. In accordance with the invention, for the elimination of this problem it is now proposed that while the annealing operation is in progress the white dust which forms is filtered out of the gas stream or streams flowing through the coolers by means of suitable filters either inside or outside the annealing apparatus.

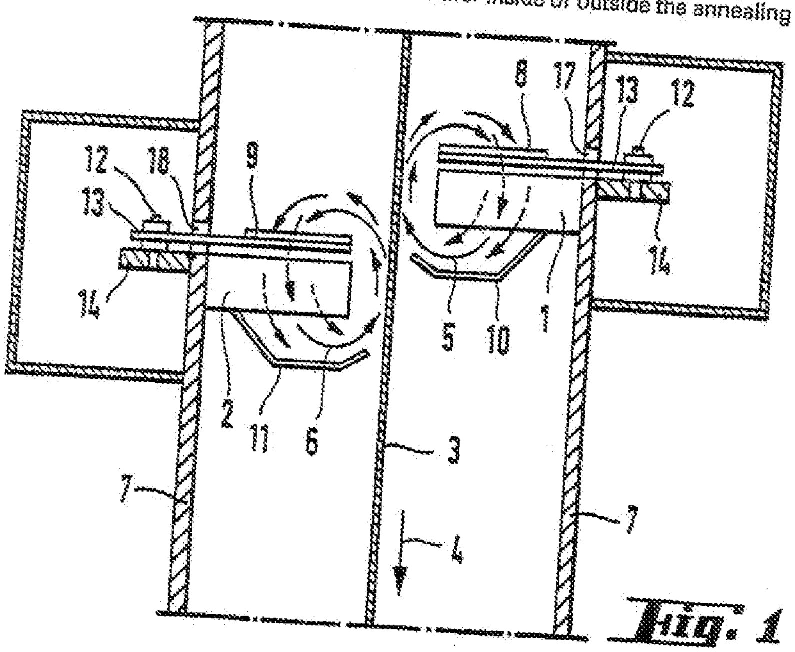

Fig. 1

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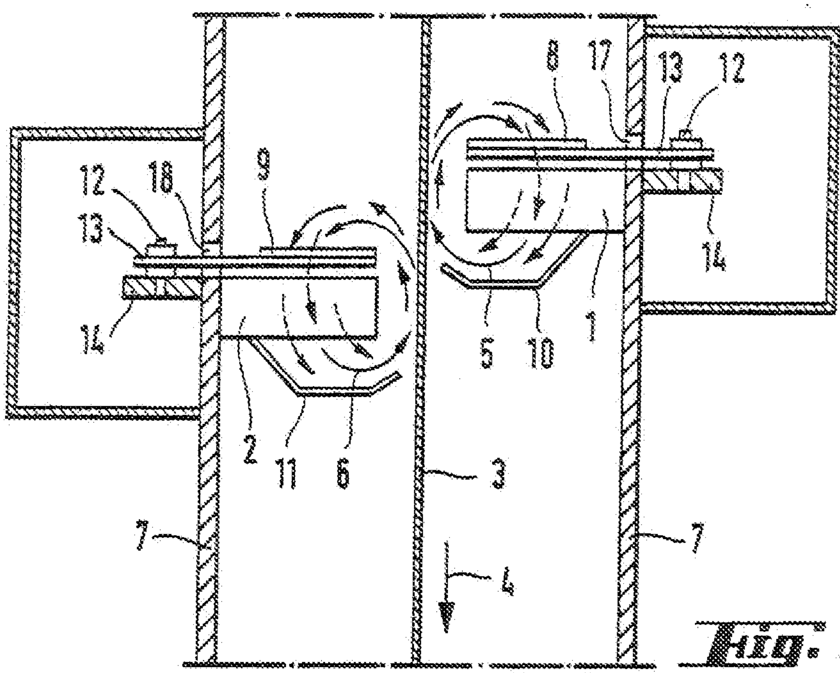

Fig. 1

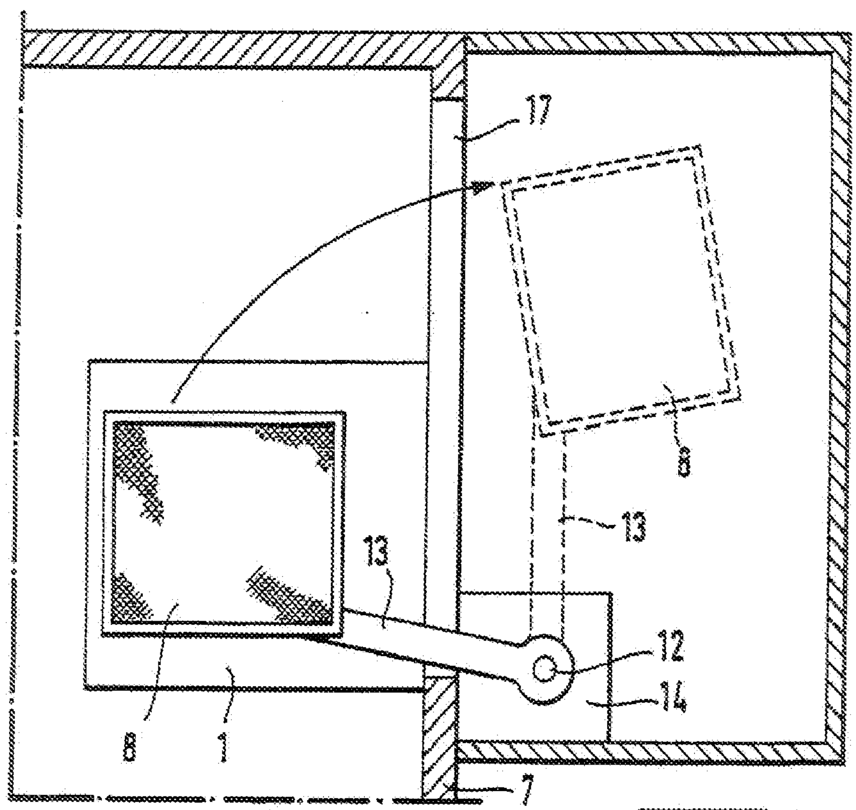

Fig. 2

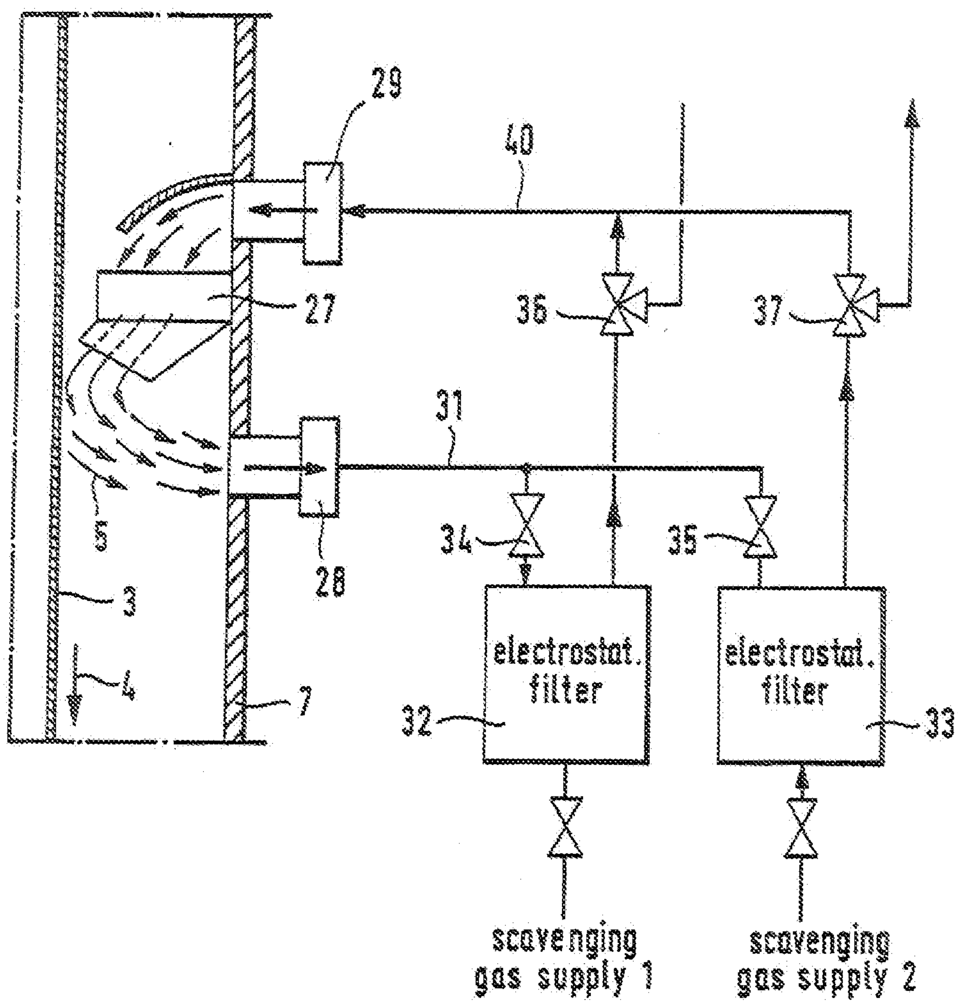
29
40
27
36
37
31
5
34
35
28
3
electrostat.
filter
electrostat.
filter
4
7
32
33
scavenging
gas supply 1
scavenging
gas supply 2

Fig. 3

A PROCESS AND APPARATUS FOR THE CONTINUOUS ANNEALING OF METALLIC MATERIAL IN THE PRESENCE OF HYDROGEN-RICH PROTECTIVE GAS

The invention relates to a process for the annealing of metallic material in a continuous fashion in a continuous annealing apparatus in which a hydrogen-rich protective gas atmosphere is maintained by a suitable supply of appropriate starting media, wherein the material to be annealed is consecutively heated, annealed and cooled again, and wherein the cooling is carried out by coolers in a cooling zone of the annealing apparatus.

In the annealing processes described in which hydrogen-rich protective gas atmospheres are used, for reasons which cannot yet be fully explained, a white dust, probably composed of boron oxides and nitrides, is formed during operation and is deposited in the annealing apparatus, mainly in the cooling zone. If the cooling of the material to be annealed in such annealing processes is achieved by coolers arranged in the cooling zone, the action of these heat exchangers, to extract heat from the material to be annealed, is impaired by the white dust deposited in the heat exchangers. Here the heat exchangers or coolers which are used consist in particular of tubular heat exchangers equipped with fans or circulating blowers in which water is used as heat transfer medium. The white dust which becomes lodged in the cooling fins of the coolers can accumulate to form closed layers and can considerably reduce the passage through the coolers of the protective gas which is to be cooled. Furthermore, the cooling effect is distinctly reduced by the insulating effect of the dust layer. The result is a reduction in performance of the cooling of the material to be annealed and of the annealing apparatus as a whole. This can reach such a point that the throughput capacity of a corresponding annealing apparatus, for example of a band annealing apparatus, can be reduced over a period of time to such an extent that it finally falls to a level no longer tolerable in terms of plant economy. Cleaning of the coolers is then unavoidable, for which purpose it has previously been necessary to

switch off the respective annealing apparatus and disassemble the clogged heat exchangers. In more recent annealing apparatus, in which this problem has already been taken into consideration, it is known to improve the situation by installing the heat exchangers in such manner that these can easily be removed from the furnace by means of a drawer-like installation, while the furnace can remain closed by slide-like devices. This facilitates a comparatively simple and rapid cleaning with a reduced period of disuse in which the furnace need only partially cool (see the magazine "Stahl und Eisen" 107 (1987) No. 6, pages 267-273, in particular 271, lower right-hand column).

In spite of the improvement achieved by means of the described procedure, and also in spite of other proposals aimed at fundamentally avoiding the reaction leading to the production of the white dust (see e.g. DE 37 33 884 and DE 39 26 417), the problem of a reduction in the performance of annealing apparatus and ultimate interruptions in operation caused by the formation of white dust, has not yet been resolved to complete satisfaction.

Therefore an objective of the present invention is to improve upon the annealing processes described in the introduction to the description in such manner that the negative effects of the formation of white dust in such annealing processes due to the clogging of the cooling assemblies can be reduced or entirely prevented.

This aim is fulfilled, in accordance with the invention, in that while the annealing operation is in progress the white dust which forms during such heat treatments is at least partially filtered out of the gas stream or streams flowing through the coolers by the use of suitable filters, either inside or outside the annealing apparatus. In accordance with the Applicant's findings, so-called electric filters (frequently also known as electrostatic filters) can be used particularly effectively for this purpose. However, it is also possible to use other filter systems, e.g. screen filters, bag filters or granular bed filters. Suitable filters are

obtainable from the relevant dust filter manufacturers with the appropriate design and dimensioning specifications.

The filtering is also carried out advantageously in that in respect of each gas stream which is to be purified, two filters are used of which one is in each case in operation while the second is subjected to cleaning and/or regeneration, and where the two mutually associated filter units are regularly exchanged. This design variant permits continuous filter operation.

The proposal according to the invention thus improves the operation of heat treatment apparatus in that by virtue of the filtering employed in accordance with the invention, white dust is continuously captured before it can be deposited at undesired locations. In this way, specifically in the case of cost-intensive band annealing apparatus in which the material throughput is very high, advantages are achieved - albeit with a certain outlay. Thus, by means of the procedure according to the invention, the disadvantages associated with the precipitation of dust, in particular the clogging of the coolers, are overcome to such an extent that these no longer constitute a limiting factor in the operation of such apparatus.

Embodiments of the invention will now be explained in detail with reference to the accompanying drawings, in which:

Figure 1 is a side view, in section, of a portion of a cooling stage of a band annealing apparatus, with two combined gas circulators and coolers with preceding screen filters;

Figure 2 is a frontal view of one of the circulating and cooling devices seen in Figure 1, and in particular of the installation of an associated, electrostatic filter; and

Figure 3 illustrates schematically a segment of an annealing apparatus with dust separation outside the annealing apparatus by means of a pair of electric filters.

Referring now to Figure 1, there is seen a portion of the cooling stage of a continuous annealing apparatus 7 for steel bands, in which the steel band has been referenced 3. In particular, Figure

1 also shows the arrangement of two circulating and cooling devices 1, 2 (referred to below as 'coolers') in this part of the apparatus. These coolers 1, 2 serve to rapidly cool the steel band 3 by the production of a cooled protective gas stream 5, 6 which contacts the steel band 3. Baffles 10, 11 impart a suitable circulating formation to the cooling protective gas streams 5, 6. Here only two of a normally greater number of coolers have been shown. The arrow 4 indicates the direction of movement of the annealed steel band 3. The outer walls of the illustrated portion of the furnace have been referenced 7. Upstream of the coolers 1, 2 metallic screen filters 8, 9 are arranged in the respective associated protective gas streams 5 and 6. These filters can be removed from within the annealing apparatus through openings 17, 18 provided in the furnace wall, which openings are sealed from the environment by gas-tight chambers 20 on the exterior of the annealing apparatus.

Figure 2 is a view of the cooler 1 with filter 8 and associated environment seen in the direction of travel 4 of the strip 3, where the parts with identical references to those of Figure 1 are given like references. Figure 2 illustrates the position of the filter 8 in the operating state (solid lines) and in the removed state (broken lines). The actual filter element of the filter 8 is supported by a carrier arm 13. The carrier arm 13 is connected to a pivot pin 12 outside of the annealing apparatus, said pivot pin 12 being rotatably mounted in a bearing 14. By rotating the arm 13 about the pivot pin 12, the filter unit 8 can be swung through opening 17 to the position outside the annealing apparatus indicated by broken lines in Figure 2 and in this position - after the closure of the openings 17, 18 and the opening of the chamber 20 - can be subjected to cleaning. This cleaning is carried out while the apparatus is in operation, at which time obviously no filtering of dust takes place. As, however, cleaning is required at intervals ranging from only several hours to days and the cleaning occupies only a comparatively short period of time, the effectiveness of the filtering is not substantially thereby reduced.

Overall, in this way it is possible to filter a substantial part of the white dust circulated with the cooling protective gas stream, and thus to prevent the accumulation of said dust in the coolers.

To illustrate the quantity of dust involved, it has been found that in the case of an average band annealing apparatus with a material throughput of 10 t/h, approximately 1.5 kg B_2O_3 (boron oxide) is formed each week. After a conventional apparatus operation of about six weeks, due to a reduction in the efficiency of the coolers this amount reduces the throughput capacity of the apparatus in such manner that a break in operation is necessary in order to clean or replace the coolers.

In the above described example, as stated, a filter is operated until the filter has become clogged to a specified degree and the filter is cleaned with an interruption in the activity of the filter. Figure 3 now illustrates a variant in which the filtering activity is uninterrupted. In this particularly efficient variant of the process according to the invention, dust-laden protective gas is de-dusted outside of the annealing apparatus, of which latter the wall 7 has been shown.

Here the protective gas is conveyed by means of circulating devices 28, 29 arranged outside the apparatus. Such cooling gas circulation leading out of the apparatus and based on circulating blowers is known in practice in association with such annealing apparatus and is in common use. The element referenced 27 in Figure 3 represents a tubular cooler conveying cooling water which is traversed by the circulating protective gas stream 5 in the direction of the arrows. While only one pair of circulating devices 28, 29 is shown, there may in practice be a plurality of such pairs with each pair having an associated cooler 27.

The protective gas is firstly sucked out of the annealing apparatus by the extracting circulating device 28, and is fed via a gas line 31, which may be common to all the extraction circulators, to one of a pair of electric or electrostatic filters 32, 33 which

can be switched on in alternation. The filter 32 is currently engaged in filter operation, as indicated in the drawing by the arrows on the connecting lines, while the filter 33 is being cleaned - for example by a beating device and a gas stream. In this state, valve 34 is open, and valve 35 closed. Valve 36 directs filtered gas from filter 32 to the return line 40. Having passed through the active filter, the protective gas is returned into the annealing apparatus via a gas line 40 and optionally a gas distributor. Here the provision of the additional circulating fan 29 in the return line 40 is advantageous in terms of maintaining a specified quantity of circulating gas.

In any case, however, the white dust is efficiently filtered out of the protective gas by means of the active electric filter - here the electric filter 32. After an interval of time to be adapted to the respective filter unit, the operating states of the two filters 32, 33 must then be switched over. In the present example this switch-over is facilitated by closing the valves 34 to cut off the filter 32 from the gas stream emanating from the annealing apparatus and opening valve 35 to conduct the gas stream to the filter unit 33. Valve 37 is opened to direct the gas from filter 33 to the return line 40.

Before the switch-over to the cleaned filter 33 takes place, the filter 33 must be flushed with a suitable flushing gas so that after the switch-over no harmful gases, in particular no oxygen, is introduced into the annealing apparatus. Expedient flushing gases are nitrogen or hydrogen, as these also constitute the protective gas used in the furnace and therefore the supply of one of these gases - or a mixture thereof - should be possible without a substantial additional outlay. The flushing gases are introduced into the respective filter units 32, 33 via valves 41, 42 when the filter concerned has been cleaned and before the associated valve 34 or 35 is opened. Flushing or scavenging gas fills the filter and is allowed to escape via associated valve 36 or 37, which is set to direct the scavenging gas not to the return line 40 but to an outlet 43 or 44.

With this embodiment of the invention a particularly extensive de-dusting of the protective gas is achieved in the described annealing processes. This process variant obviously also involves some outlay, however, although this should be included in considerations relating to the process economy and weighed against the advantages. However, it is in the case of the high-performance but cost-intensive band annealing apparatus of special relevance here that the process proposed in accordance with the invention is of particular significance. Finally it should again be generally noted that by means of the proposal according to the invention, the effects of the formation of "white dust" in annealing treatments of metallic material can be distinctly reduced, resulting in the possibility of operating associated annealing apparatus in an improved fashion in this sense.

CLAIMS

1. A process for annealing metallic material in a continuous fashion in a continuous annealing apparatus in which a hydrogen-rich protective gas atmosphere is maintained by a suitable supply of appropriate starting media, wherein the material to be annealed is consecutively heated, annealed and cooled again and wherein the cooling is carried out in a cooling zone of the annealing apparatus supported by coolers, characterised in that while the annealing operation is in progress the white dust which forms in the case of such heat treatments is filtered out of the gas stream or streams flowing through the coolers by means of suitable filters either inside or outside the annealing apparatus.

2. A process as claimed in Claim 1, characterised in that electric filters are used as filters.

3. A process as claimed in one of Claims 1 or 2, characterised in that in respect of each gas stream which is to be purified, two filters are used of which one is in each case engaged in operation while the second is subjected to cleaning and regeneration and wherein the two mutually associated filter units are regularly exchanged.

4. A process as claimed in one of Claims 1 to 3, characterised in that the cleaned filter shortly to enter into filter operation is flushed with a suitable gas, for example with a main constituent of the protective gas or with the protective gas itself.

5. A process according to Claim 1, wherein the filtering of the gas stream takes place within the annealing apparatus, and wherein the filter is movable to a position outside the annealing apparatus for cleaning.

6. A process substantially as herein described with reference to the accompanying drawings.

7. An apparatus for continuously annealing a metallic strip, comprising means for cooling and circulating a gas stream over the surface of the strip, and further comprising a filter movable between

an operative position within the apparatus wherein it serves to filter the gas stream, and an inoperative position wherein it is situated outside the apparatus and may be isolated therefrom for cleaning.

8. An apparatus substantially as herein described with reference to Figures 1 and 2 or Figure 3 of the accompanying drawings.

Patents Act 1977 Examiner's report to the Comptroller under Section 17 (The Search report)	Application number GB 9316091.9
Relevant Technical Fields (i) UK Cl (Ed.L) C7N (ii) Int Cl (Ed.5) C21D	Search Examiner R B LUCK Date of completion of Search 1 DECEMBER 93
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) WPI	Documents considered relevant following a search in respect of Claims :- 1-8

Categories of documents

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P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
X	US 5158625 (L AIR LIQUIDE SOC.)	1 AT LEAST
X	US 4398971 (AGA AB)	1 AT LEAST
X	JP 62177126 (NIPPON KOLAN K.X.)	1 AT LEAST
X	JP 51100917 (KOBE STEEL KK)	1 AT LEAST

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